(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
6 June 2002 (06.06.2002)

PCT

(10) International Publication Number
WO 02/43976 A1

(51) International Patent Classification[7]: B60G 11/02, 11/04, 21/055

(21) International Application Number: PCT/US00/32527

(22) International Filing Date:
28 November 2000 (28.11.2000)

(25) Filing Language: English

(26) Publication Language: English

(71) Applicant *(for all designated States except US)*: **DETROIT STEEL PRODUCTS CO., INC.** [US/US]; 500 North Rangeline Road, Morristown, IN 46161 (US).

(72) Inventors; and

(75) Inventors/Applicants *(for US only)*: **GLASS, Michael, F.** [US/US]; 4905 Carry Back Lane, Indianapolis, IN 46237 (US). **REAST, John, B.** [GB/GB]; Helpringham House, 10 Kimbolton, Bedford MK40 2NR (GB).

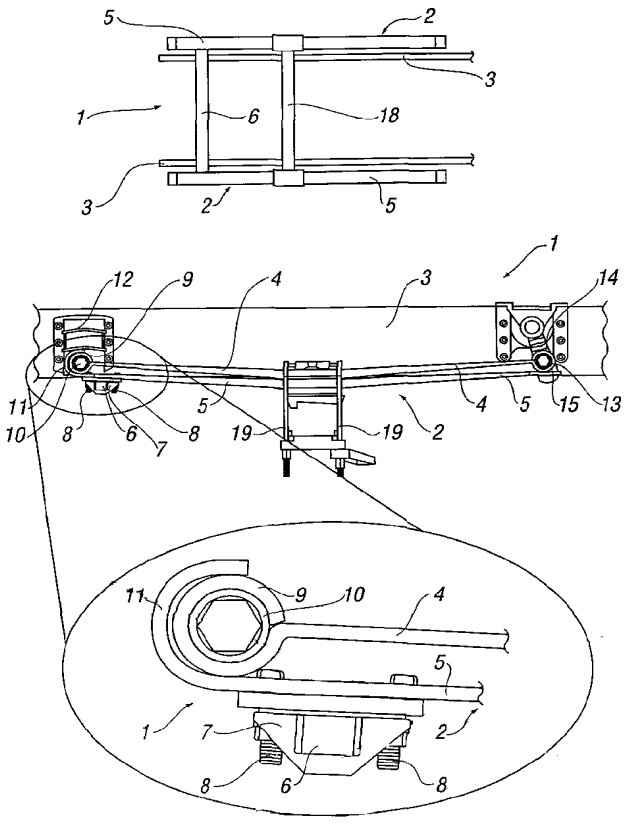
(74) Agents: **FILDES, Christopher, J.** et al.; Fildes & Outland, P.C., Suite 2, 20916 Mack Avenue, Grosse Pointe Woods, MI 48236 (US).

(81) Designated States *(national)*: AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, BZ, CA, CH, CN, CR, CU, CZ, DE, DK, DM, DZ, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, TZ, UA, UG, US, UZ, VN, YU, ZA, ZW.

(84) Designated States *(regional)*: ARIPO patent (GH, GM, KE, LS, MW, MZ, SD, SL, SZ, TZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European

[Continued on next page]

(54) Title: MULTI-LEAF SPRING VEHICLE SUSPENSION WITH AN ANTI-ROLL BAR



(57) Abstract: A suspension for a vehicle includes a pair of multi-leaf springs arranged to extend longitudinally of the frame or chassis of an associated vehicle. Each multi-leaf spring includes a single, main leaf and a single secondary spring leaf. An anti-roll or stabilizer is arranged to extend transversely of the frame or chassis and has its opposed ends connected rigidly to respective ones of the pair of secondary spring leaves. A torque transfer mechanism is connected rigidly to each of the pair of secondary spring leaves, which engages with each of the pair of main spring leaves and which is capable or relative longitudinal movement with respect thereto.

WO 02/43976 A1

patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE, TR), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GW, ML, MR, NE, SN, TD, TG).

Published:

— *with international search report*

— *before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments*

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

MULTI-LEAF SPRING VEHICLE SUSPENSION WITH AN ANTI-ROLL BAR

This invention relates to a multi-leaf spring vehicle suspension by which a vehicle can be suspended from at least one pair of multi-leaf springs extending longitudinally of the vehicle on respective opposed sides thereof, with the axle of the vehicle being mounted generally centrally of the springs which are mounted to the vehicle, such as the frame or chassis thereof, at their opposed ends.

In use, the springs isolate the vehicle from inputs into the suspension created by the roughness of the road surface upon which the vehicle travels. Generally, the softer the load/deflection rate of the spring (hereinafter referred to as "the spring rate"), the better the isolation. However, this spring rate is a compromise between several factors. Two major factors are, firstly the softness to obtain the best isolation and, secondly, the need for higher stiffness to provide stability when the vehicle is cornering or is subjected to side forces, such as those generated by side winds.

This compromise can be, and has been, improved by the addition of vehicle anti-roll devices. Historically, such devices have included additional tension springs which, externally of the main leaf springs, add stiffness to the suspension when the axle undergoes different movements relative to the vehicle from side to side. This is the relative motion between the axle and vehicle when the vehicle rolls.

These anti-roll devices provide only a limited improvement to the compromised spring rates discussed above, as much of the isolation of the vehicle is from road surface inputs on one side of the vehicle, which deflects the axle in a similar manner to that with vehicle roll.

Recently, a newly-modified anti-roll device has been developed, which operates by stiffening the leaf springs internally when the vehicle effectively rolls. In its simplest form, this integral anti-roll device stabilises the leaf springs by changing the leaf spring deflection rates from the regular pin-jointed beam rate, when the springs deflect in the same direction, to a rigid, fixed or encastre end-mounted beam rate when the springs deflect in opposite directions, as they do when the vehicle rolls. This fixed end beam rate can be up to four times as stiff as the pin-jointed beam rate.

The effect of this newly-modified anti-roll device is achieved by mounting a bar or tube between the ends of the leaf springs of the pair of leaf springs on respective opposed sides of the vehicle, where the springs are normally mounted to the vehicle at one end thereof.

As previously stated, the basic principle of this device is that when the springs deflect normally, in the same direction, the bar or tube has no effect and the springs have the normal conventional deflection rate. When the vehicle rolls, such as when travelling around a corner, the springs deflect in opposite directions. When this happens, the bar or tube torsionally resists such deflections, creating a fixing moment on to the springs, thus stiffening them as if the end fastenings were rigidly mounted. However, the bar or tube can only be effective on one leaf of any multi-leaf spring, because the bar or tube has to be rigidly mounted to the spring leaves and the spring leaf ends have to be able to move relative to each other.. Also, if the bar or tube is mounted only to one end of the spring, the stabilisation applies to only one cantilever of one leaf.

Thus, because the current device can be attached to only one cantilever of one leaf of each leaf spring, as the number of leaves used in each spring increases, the effectiveness of this anti-roll device is limited.

An object of the present invention is to provide a multi-leaf spring suspension which overcomes, or at least substantially reduces, the disadvantages associated with the known leaf spring suspensions discussed above.

Another object of the present invention is to provide a multi-leaf spring suspension which can be mounted to a vehicle using conventional frame or vehicle chassis mounting devices, such as hanger brackets, and without special anti-roll system brackets, this being advantageous because, in many cases, hanger brackets form part of a common frame assembly which can also be used with stiffer, non anti-roll stabilised springs.

Accordingly, one aspect of the invention resides in a suspension for a vehicle, comprising:

a pair of multi-leaf springs arranged to extend longitudinally of the frame or chassis of an associated vehicle on respective opposed sides thereof, each multi-leaf spring comprising a single, main spring leaf and a single secondary spring leaf;

anti-roll or stabilising means arranged to extend transversely of the frame or chassis of the associated vehicle and having its opposed ends connected rigidly to respective ones of the pair of secondary spring leaves; and

torque transfer means which is connected rigidly to each of the pair of secondary spring leaves, which engages with each of the pair of main spring leaves and which is capable of relative longitudinal movement with respect thereto.

Another aspect of the invention resides in a vehicle including a frame or chassis and a suspension, comprising:

a pair of multi-leaf springs extending longitudinally of the frame or chassis on respective opposed sides thereof, each multi-leaf spring comprising a single, main spring leaf and a single secondary spring leaf;

anti-roll or stabilising means extending transversely of the frame or chassis and having its opposed ends connected rigidly to respective ones of the pair of secondary spring leaves; and

torque transfer means which is connected rigidly to each of the pair of secondary spring leaves, which engages with each of the pair of main spring leaves and which is capable of relative longitudinal movement with respect thereto.

Said torque transfer means is capable of transmitting at least some of the torque generated by the anti-roll or stabilising means, in use, to each of the single, main spring leaves via the respective single, secondary spring leaves to which the ends of the anti-roll or stabilising means are rigidly connected.

Preferably, the torque transfer means comprises a bracket having one end connected rigidly to each of the pair of single, secondary spring leaves and having its other end engaging each of the pair of single, main spring leaves for relative longitudinal movement with respect thereto. The other end of each torque transfer means may comprise and be connected to an element arranged in sliding engagement with the respective main spring leaf. Alternatively or additionally, the element may be secured to at least the other end of its torque transfer bracket and may be resiliently deformable, such that, in use, it is capable of allowing relative movement between the bracket , and hence the secondary spring leaf, and the main spring leaf.

The one end of each main spring leaf may be mounted to the corresponding one end of each secondary spring leaf by means of an interleaf element located between said spring leaf ends. Preferably, the one end of each main spring leaf comprises an eye, such as a Berlin eye, which is connectable or connected to the frame or chassis of the vehicle via a bush or shackle which is mounted to the corresponding one end of each secondary spring leaf by means of the interleaf elements located between said spring leaf ends.

The end of each secondary spring leaf remote from the end thereof to which the anti-roll or stabilising means is rigidly connected, may be mounted to a corresponding shackle in sliding engagement therewith. Preferably, such mounting is by way of a pin arranged on an extension of each shackle and upon which the corresponding end of each secondary spring leaf bears.

At least one of the main and secondary spring leaves of each multi-leaf spring may be pre-loaded, either during manufacture or assembly. Preferably, both the main and secondary spring leaves of each multi-leaf spring are so pre-loaded.

The anti-roll or stabilising means preferably comprises an anti-roll or stabiliser bar or tube.

In a modification of embodiments of the first and second aspects of the invention, the end of each multi-leaf spring remote from the end to which the anti-roll or stabilising means is connected, is provided with means, such as a clip, connected rigidly to each of the pair of secondary spring leaves and engaging each of the pair of main spring leaves for relative longitudinal movement with respect thereto. This arrangement can improve the balance and performance of the suspension.

In order that the invention may be more fully understood, preferred embodiments of inventive multi-leaf spring suspension will now be described by way of example and with reference to the accompanying drawings in which:

Figures 1 and 2 are respective bottom plan and side elevational views of a first prior art, multi-leaf spring suspension;

Figure 3 is a side elevational view of part of the suspension shown in Figures 1 and 2, on an enlarged scale;

Figure 4 and 5 are respective bottom plan and side elevational views of a second prior art, multi-leaf spring suspension;

Figure 6 is a side elevational view of part of the suspension shown in Figures 4 and 5, on an enlarged scale;

Figure 7 and 8 are respective bottom plan and side elevational views of a first embodiment of multi-leaf spring suspension in accordance with the invention;

Figure 9 is a side elevational view of part of the first embodiment of suspension shown in Figures 7 and 8, on an enlarged scale;

Figure 10 and 11 are respective bottom plan and side elevational views of a second embodiment of multi-leaf spring suspension in accordance with the invention;

Figure 12 is a side elevational view of part of the second embodiment of suspension shown in Figures 10 and 11;

Figure 13 is a side elevational view of one end of a third embodiment of multi-leaf spring suspension; and

Figure 14 is a side elevational view of another end of a fourth embodiment of multi-leaf spring suspension.

Referring firstly to Figures 1 to 3, a first, typical prior art multi-leaf spring suspension indicated generally at 1, comprises a pair of multi-leaf springs shown generally at 2 and extending longitudinally of a vehicle frame or chassis 3 on respective opposed sides thereof. Each multi-leaf spring 2 comprises a single primary spring leaf 4 and a single secondary spring leaf 5. An anti-roll or stabiliser bar or tube 6 extends transversely of the vehicle frame or chassis 3, with its opposed ends connected rigidly to respective forward ends of the pair of secondary spring leaves 5 by means of a clamp 7 and bolts 8.

At the forward end of each multi-leaf spring 2, the main spring leaf 4 has a Berlin eye 9 connected to a frame or chassis-mounted bush 10, whilst the forward end 11 of the secondary spring leaf 5 is wrapped partially around the Berlin eye 9 of the main spring leaf 4 to provide a military wrap.

At the rear end of each multi-leaf spring 2, the main spring leaf 4 again has a Berlin eye 13 connected to a frame or chassis-mounted shackle 14 with the rear end 15 of the secondary spring 5 and the eye 13 bearing against each other.

Mounted generally centrally of the pair of multi-leaf springs 2 are respective opposed ends of a transverse axle 18, such mounting being effected by a pair of U-bolts 19.

Referring now to Figures 4 to 6, here is shown a second, typical prior art multi-leaf spring suspension 1 which is similar to that described above in relation to Figures 1 to 3 and in which the same components are referenced by like numerals to those of Figures 1 to 3, except that the anti-roll or stabiliser bar or tube 6 has its opposed ends connected rigidly to respective rear ends 15 of the pair of secondary spring leaves 5.

At higher vehicle roll conditions, the torque applied to the secondary spring leaves 5 requires a reaction force to prevent the secondary spring leaves 5 lifting out of engagement with the respective primary spring leaves 4 at the ends thereof. In this case, much of the torque transmitted to the secondary spring leaves 5 is lost, thereby reducing the anti-roll effect. In the prior art suspension 1 described above in relation to Figures 1 to 3, this reaction force is provided by the military wraps 11 at the forward end of the suspension 1, whilst, in the prior art suspension 1 described above in relation to Figures 4 to 6, such force is provided by a pin 16 of a shackle extension 17 at the rear end of the suspension.

For practical reasons, there should be some clearance gaps between each secondary spring leaf 5 and the corresponding torque reaction point, provided by the military wrap 11 or pin 16, sometime during spring deflection or spring assembly life. This can produce knocking noised from the suspension which can give refinement problems on some vehicle suspension applications.

Referring now to Figures 7 to 9, here is shown a first embodiment of a multi-leaf vehicle suspension 20 which is similar to that described above in relation to Figures 1 to 3 and in which the same components are referenced by like numerals to those in Figures 1 to 3. However, and in accordance with the invention, there is provided a bracket 21 having its one, lower end secured rigidly, by means of the clamp 7 and bolts 8, to each single, secondary spring

leaf 5 to which the corresponding end of the anti-roll or stabiliser bar or tube 6 is rigidly connected.

The other, upper end 23 is connected, via a pin 24, to an element 25 which is in slidable longitudinal engagement with the upper surface 26 of the single, main spring leaf 4.

The Berlin eye 9 at the forward end of the main spring leaf 4 is mounted upon an interleaf element 27 mounted upon the upper surface 28 of the secondary spring leaf 5.

In use of this first embodiment of suspension 20, torque from the anti-roll or stabiliser bar or tube 6 is transmitted via the secondary spring leaf 5 to the main spring leaf 4 through the bracket 21 and slidable element 25. This torque which is applied to the main spring leaf 4 is created by opposing forces between the interleaf element 27 and the slidable element 25. Such interleaf element 27 is not absolutely necessary but, in certain circumstances, is desirable to reduce friction within the suspension 20.

When the force at the slidable element 24 is directed away from the upper surface 26 of the main spring leaf 4, such force tends to lift the element 25 out of engagement from that upper surface 26. This problem may be overcome by pre-loading the main and secondary spring leaf 4,5 with a sufficiently pre-loaded force, during assembly, to resist the maximum, or a substantial proportion, of any moment of the anti-roll or stabilising bar or tube 6.

Thus, this pre-load on the main and secondary spring leaves, 4, 5, even under anti-roll or stabilising conditions, assists in maintaining the spring leaves 4,5 in contact with each other, thereby eliminating, or at least

substantially reducing, any knocking noises from the suspension 20, which improves the refinement of the suspension in many applications.

Referring now to Figures 10 to 12, here is shown a second embodiment of a multi-leaf vehicle suspension 30 which is similar to that described above in relation to Figures 4 to 6 and in which the same components are referenced by like numerals to those in Figures 4 to 6. However, and in accordance with the invention , there is provided a bracket 31 having its one, lower end secured rigidly, by means of the clamp 7 and bolts 8, to the single, secondary spring leaf 5 to which the anti-roll or stabiliser bar or tube 6 is rigidly connected.

The other, upper end 33 is connected, via a pin 34, to an element 35 which is in longitudinal slidable engagement with the upper surface 36 of the single, main spring leaf 4.

The Berlin eye 13 at the rear end of the main spring leaf 4 is mounted upon an interleaf element 37 mounted upon the upper surface 38 of the secondary spring leaf 5.

In use of this second embodiment of suspension 30, torque from the anti-roll or stabiliser bar or tube 6 is transmitted via the secondary spring leaf 5 to the main spring leaf 4 through the bracket 31 and slidable element 35. This torque which is applied to the main spring leaf 4 is created by opposing forces between the interleaf element 37 and the slidable element 35. Such interleaf element 37 is not absolutely necessary but, in certain circumstances, is desirable to reduce friction within the suspension 20.

When the force at the slidable element 34 is directed away from the upper surface 36 of the main spring leaf 4, such force tends to lift the element 35 out of engagement with that upper surface 36. This problem may again be overcome by pre-loading the main and secondary spring leaf 4, 5 with a

sufficiently pre-loaded force, during assembly, to resist the maximum, or a substantial proportion, of any moment of the anti-roll or stabilising bar or tube 6.

Thus, this pre-load on the main and secondary spring leaves, 4, 5, even under anti-roll or stabilising conditions, assists in maintaining the spring leaves 4, 5 in contact with each other, thereby eliminating, or at least substantially reducing, any knocking noises from the suspension 30, which improves the refinement of the suspension in many applications.

Thus, the elements 25, 35 of both embodiments of suspension 20, 30 may be solid and in sliding engagement with the upper surfaces 26, 36 of the main spring leaf 4 to allow relative longitudinal movement of the main and secondary spring leaves 4, 5.

In a modification, the elements 25, 35, as well as the interleave elements 27, 37 may be resiliently deformable and made from rubber, polyurethane or similar material. This allows shearing of the resiliently deformable elements 25, 35 and 27, 37, rather than sliding movement, to allow relative longitudinal movement between the main and secondary spring leaves 4, 5, thus reducing any sliding friction and wear.

Referring now to Figure 13, here is shown a third embodiment of a muti-leaf vehicle suspension 40 which is similar to that described above in relation to Figures 7 to 9 and in which the same components are referenced by like numerals to those in Figures 7 to 9. However, the other, upper end 43 of the torque-transmitting bracket 41 is connected, via a bolt 44, to a resiliently deformable element 45 in engagement with the upper surface 46 of the single, main spring leaf 4.

An upturned eye 48 at the forward end of the main spring leaf 4 is mounted upon an elongate interleaf element 47 which is secured to the upper surface 47 of the secondary spring leaf 5 and which is also resiliently deformable. This arrangement may also control frictional sliding and wear between the main and secondary spring leaves 4, 5.

Thus, and in the three embodiments of inventive suspension discussed above, as torque from the anti-roll or stabiliser bar or tube 6 now bears upon both the secondary and main spring leaves 5, 4, this increases the anti-roll or stabilising stiffness and spring rate, and hence effectiveness, of the suspensions 20, 30, 40. This means that the anti-roll or stabiliser bar or tube 6 can be applied to multi-leaf vehicle suspensions with soft springs with more than two spring leaves, namely main spring leaves 4 and more than two secondary springs 5, although the anti-roll or stabiliser bar or tube 6 will almost certainly have its opposed ends connected rigidly to only one pair of secondary spring leaves 5. Also, on suspensions with only two spring leaves, namely a single main spring leaf 4 and a single secondary spring leaf 5, the size of the anti-role or stabiliser bar or tube 6, and that of its attachments, may be reduced, to save weight and cost.

With most applications for the inventive suspension, sufficient anti-roll or stabilising stiffness can be obtained with the bar or tube 6 mounted only to one end of the secondary spring leaves 5. However, the resilient pre-load between the spring leaves 4, 5 at the bar or tube end of the multi-leaf springs could make contact between, and stress distribution within, the spring leaves 4,5 uneven between the forward and rear cantilever lengths of the spring leaves. Therefore, it is proposed, as a further modification for the embodiments discussed above, to provide a clip, and possibly pre-load, on the ends of the pair of multi-leaf springs remote from the torque-transmitting means, such as the brackets 21, 31, 41. Such a clip is shown in Figure 14 at 51 at, say, the rear end of the multi-leaf springs of Figures 7 to 9. The one, lower

end 52 of each clip 51 is secured rigidly to the single, secondary spring leaf 5, whilst its other, upper end 53 is connected to the upper surface 56 of the main spring leaf 5 via an element 55 which is in slidable engagement with that upper surface 56, to allow, in use, relative longitudinal movement between the main and secondary spring leaves 4, 5. Alternatively, and as discussed above, that element 55 may be resiliently deformable, in shear, to permit relative longitudinal movement between the spring leaves 4, 5.

This clip 51 can improve the balance and performance of the suspension.

The eye 13 at the rear end of each main spring leaf 4 may be mounted to the rear end of the corresponding secondary spring leaf by means of an interleaf element 57.

It is to be appreciated that certain features of the invention, which are, for clarity, described in the context of separate embodiments, may also be provided in combination in a single embodiment. Conversely, various features of the invention, which are, for brevity, described in the context of a single embodiment, may also be provided separately or in any suitable sub-combination.

CLAIMS

1. A suspension for a vehicle comprising:

a pair of multi-leaf springs arranged to extend longitudinally of the frame or chassis of an associated vehicle on respective opposed sides thereof, each multi-leaf spring comprising a single, main spring leaf and a single secondary spring leaf;

anti-roll or stabilising means arranged to extend transversely of the frame or chassis of the associated vehicle and having its opposed ends connected rigidly to respective ones of the pair of secondary spring leaves; and

torque transfer means which is connected rigidly to each of the pair of secondary spring leaves, which engages with each of the pair of main spring leaves and which is capable of relative longitudinal movement with respect thereto.

2. A suspension according to claim 1, wherein said torque transfer means comprises a bracket having one end connected rigidly to each of the pair of single, secondary spring leaves and having its other end engaging each of the pair of single, main spring leaves for relative longitudinal movement with respect thereto.

3. A suspension according to claim 2, wherein the torque transfer means comprises and is connected to an element arranged in sliding engagement with the respective main spring leaf.

4. A suspension according to claim 2, wherein the element is secured to at least the other end of its torque transfer bracket and is resiliently deformable.

5. A suspension according to claim 1, wherein the one end of each main spring leaf is mounted to the corresponding one end of each secondary spring leaf by means of an interleaf element located between said spring leaf ends.

6. A suspension according to claim 1, wherein the one end of each main spring leaf comprises an eye which is connectable to the frame or chassis of an associated vehicle via a bush or shackle which is mounted to the corresponding one end of each secondary spring leaf by means of interleaf elements located between said spring leaf ends.

7. A suspension according to claim 1, wherein the end of each secondary spring leaf remote from the end thereof to which the anti-roll or stabilising means is rigidly connected, is mountable to a corresponding shackle in sliding engagement therewith.

8. A suspension according to claim 7, wherein such mounting is by way of a pin arranged on an extension of each shackle and upon which the corresponding end of each secondary spring leaf bears.

9. A suspension according to claim 1, wherein at least one of the main and secondary spring leaves of each multi-leaf spring is pre-loaded.

10. A suspension according to claim 9, wherein both the main and secondary spring leaves of each multi-leaf spring are so pre-loaded.

11. A suspension according to claim 1, wherein said anti-roll or stabilising means comprises an anti-roll or stabiliser bar or tube.

12. A suspension according to claim 1, wherein the end of each multi-leaf spring remote from the end thereof to which the anti-roll or stabilising means is connected, is provided with means connected rigidly to each of the pair of secondary spring leaves and engaging each of the pair of main spring leaves for relative longitudinal movement with respect thereto.

13. A suspension according to claim 12, wherein said means which is connected rigidly to each of the pair of secondary spring leaves and engages each of the pair of main spring leaves, for relative longitudinal movement with respect thereto, comprises a clip.

14. A vehicle including a frame or chassis and a suspension, comprising:

a pair of multi-leaf springs extending longitudinally of the frame or chassis on respective opposed sides thereof, each multi-leaf spring comprising a single, main spring leaf and a single secondary spring leaf;

anti-roll or stabilising means extending transversely of the frame or chassis and having its opposed ends connected rigidly to respective ones of the pair of secondary spring leaves; and

torque transfer means which is connected rigidly to each of the pair of secondary spring leaves, which engages with each of the pair of main spring leaves and which is capable of relative longitudinal movement with respect thereto.

15. A vehicle according to claim 14, wherein said torque transfer means comprises a bracket having one end connected rigidly to each of the pair of single, secondary spring leaves and having its other end engaging each of the

pair of single, main spring leaves for relative longitudinal movement with respect thereto.

16. A vehicle according to claim 15, wherein the other end of each torque transfer means comprises and is connected to an element arranged in sliding engagement with the respective main spring leaf.

17. A vehicle according to claim 15, wherein the other end of each torque transfer means comprises and is connected to an element secured to at least the other end of its torque transfer bracket and resiliently deformable.

18. A vehicle according to claim 14, wherein the one end of each main spring leaf is mounted to the corresponding one end of each secondary spring leaf by means of an interleaf element located between said spring leaf ends.

19. A vehicle according to claim 14, wherein the one end of each main spring leaf comprises an eye which is connected to the frame or chassis of the vehicle via a bush or shackle which is mounted to the corresponding one end of each secondary spring leaf by means of interleaf elements located between said spring leaf ends.

20. A vehicle according to claim 14, wherein the end of each secondary spring leaf remote from the end thereof to which the anti-roll or stabilising means is rigidly connected, is mounted to a corresponding shackle in sliding engagement therewith.

21. A vehicle according to claim 20, wherein such mounting is by way of a pin arranged on an extension of each shackle and upon which the corresponding end of each secondary spring leaf bears.

22. A vehicle according to claim 14, wherein at least one of the main and secondary spring leaves of each multi-leaf spring is pre-loaded.

23. A vehicle according to claim 22, wherein both the main and secondary spring leaves of each multi-leaf spring are so pre-loaded.

24. A vehicle according to claim 14, wherein said anti-roll or stabilising means comprises an anti-roll or stabiliser bar or tube.

25. A vehicle according to claim 14, wherein the end of each multi-leaf spring remote from the end to which said anti-roll or stabilising means is connected, is provided with further means connected rigidly to each of the pair of secondary spring leaves and engaging each of the pair of main spring leaves for relative longitudinal movement with respect thereto.

26. A vehicle according to claim 25, wherein said further means comprises a clip having one end secured rigidly to each of the pair of secondary spring leaves and having its other end engaging each of the pair of main spring leaves for relative longitudinal movement with respect thereto.

27. A suspension according to claim 1, wherein each multi-leaf spring comprises two or more single, secondary spring leaves, with said torque transfer means engaging the uppermost secondary spring leaf of each pair.

28. A vehicle according to claim 14, wherein each multi-leaf spring comprises at least two secondary spring leaves, with said torque transfer means engaging the uppermost secondary spring leaf of each pair.

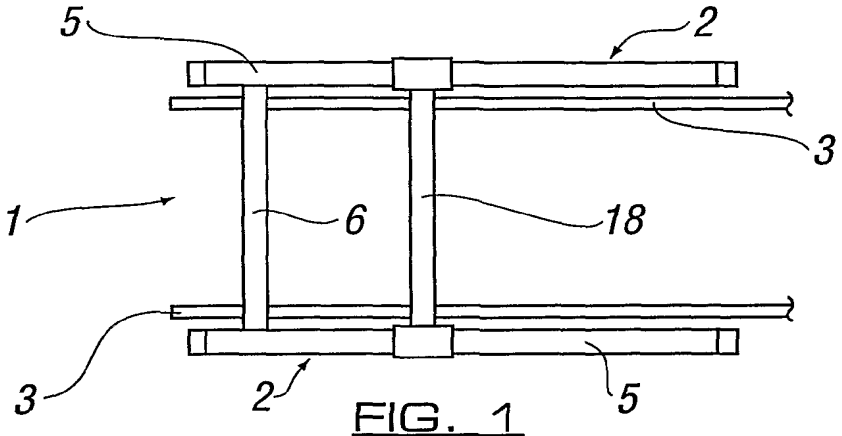


FIG. 1

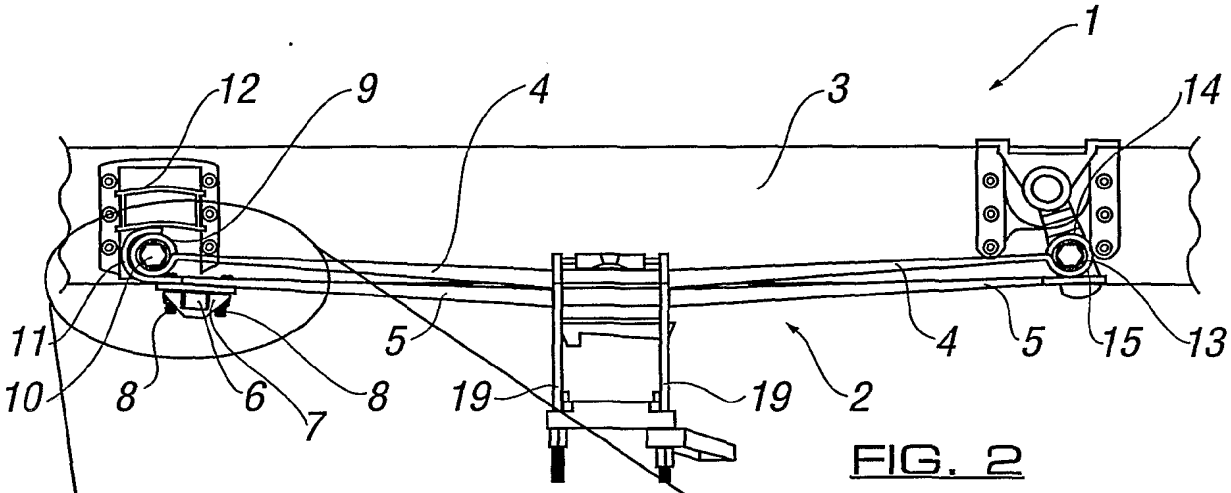


FIG. 2

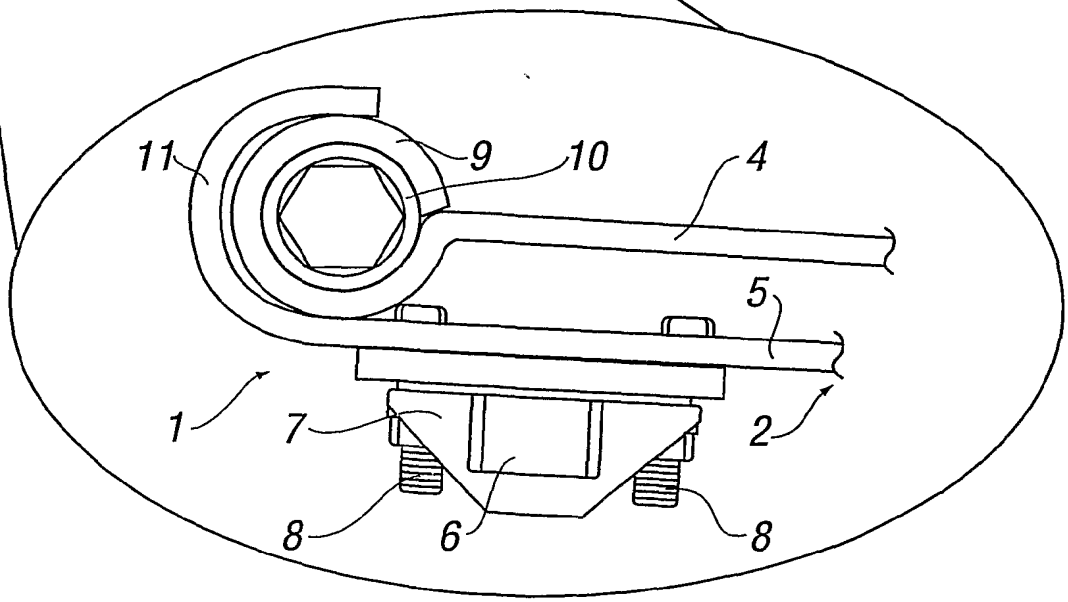


FIG. 3

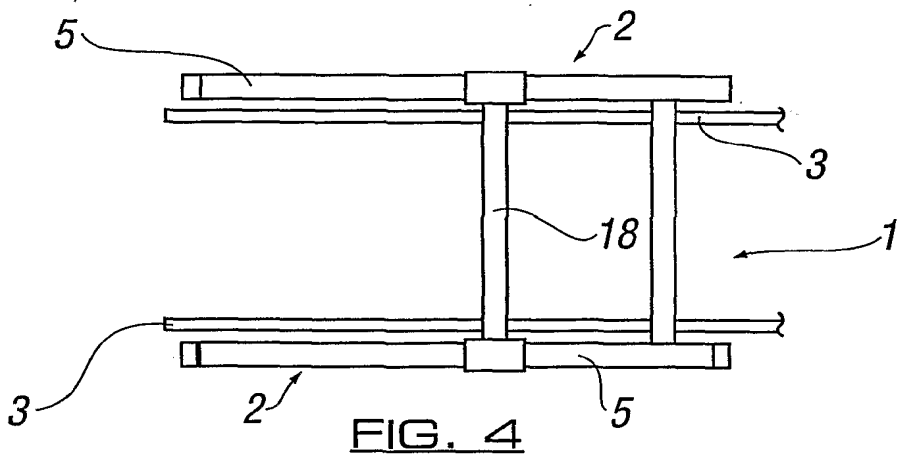


FIG. 4

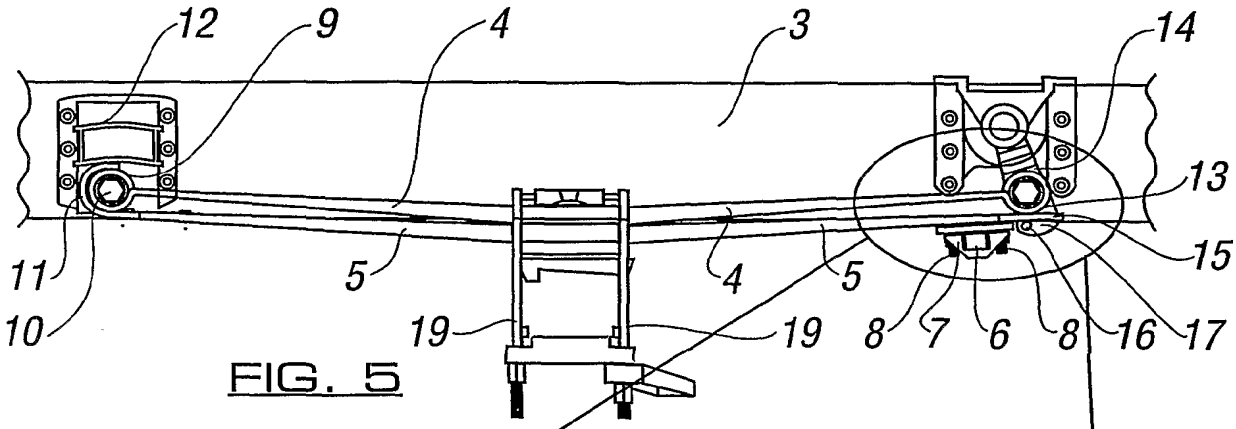


FIG. 5

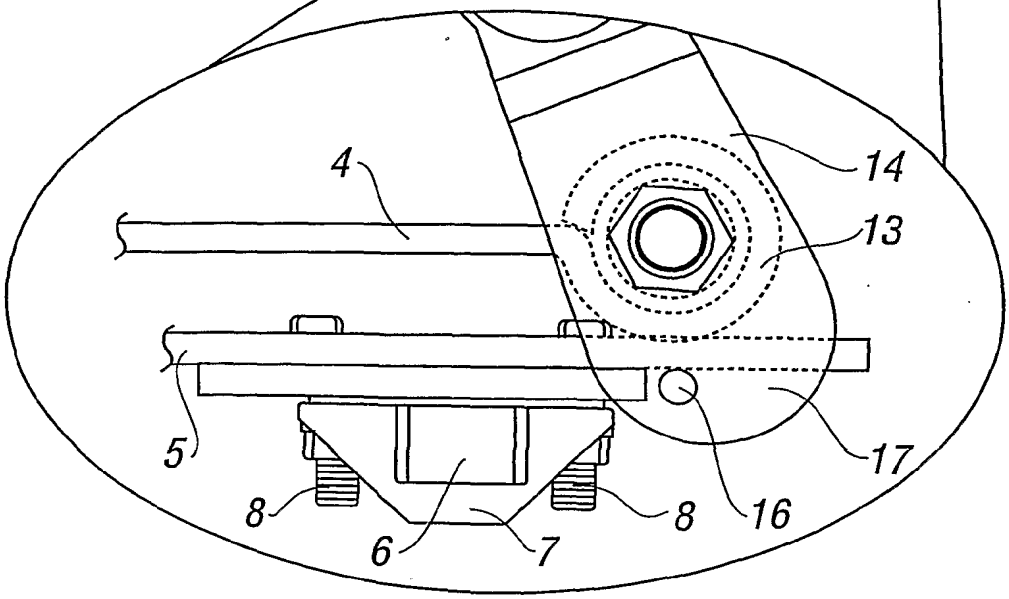


FIG. 6

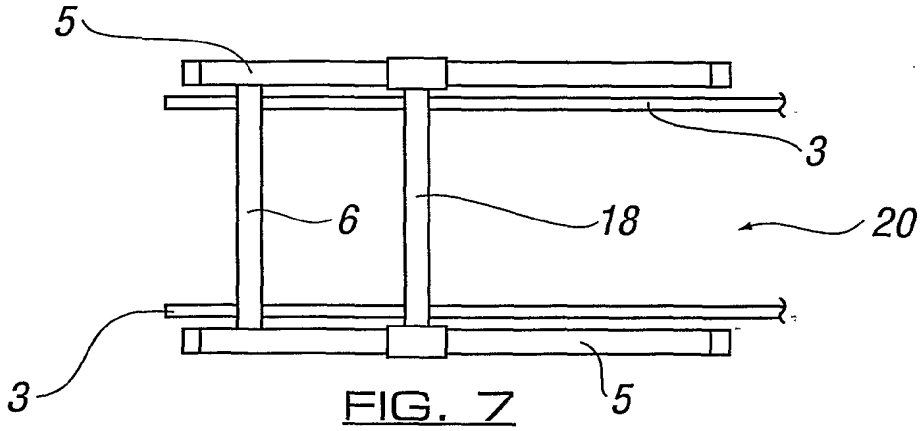


FIG. 7

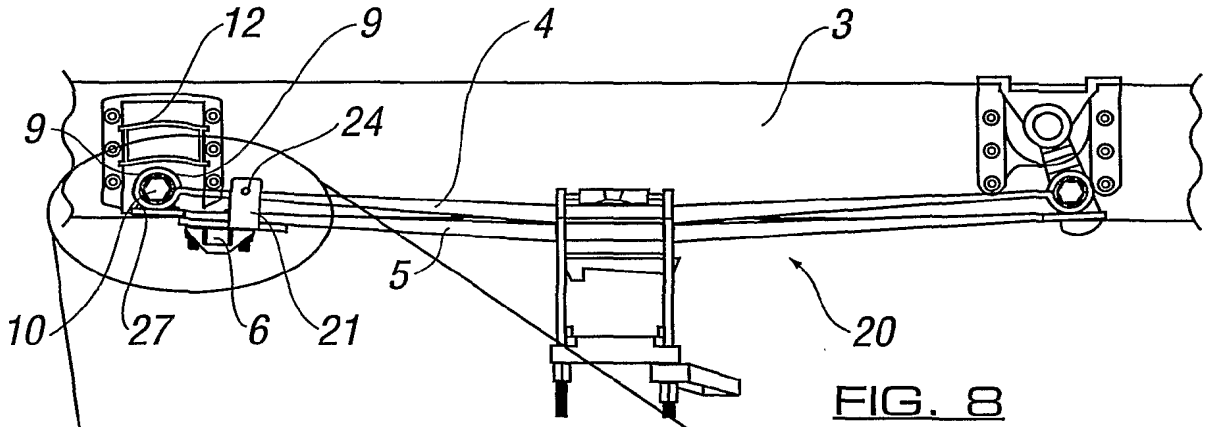


FIG. 8

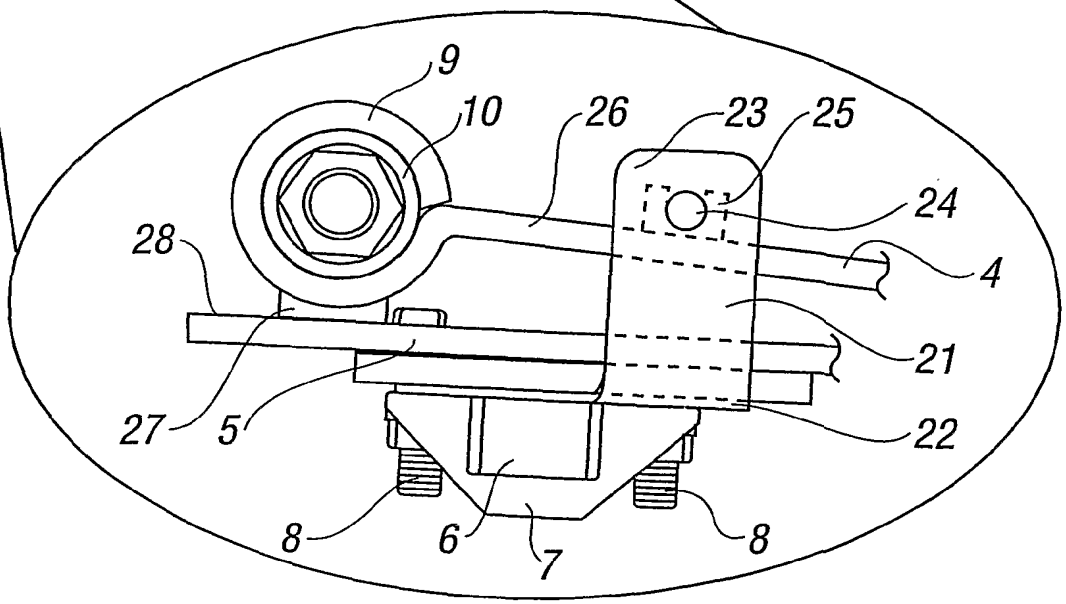


FIG. 9

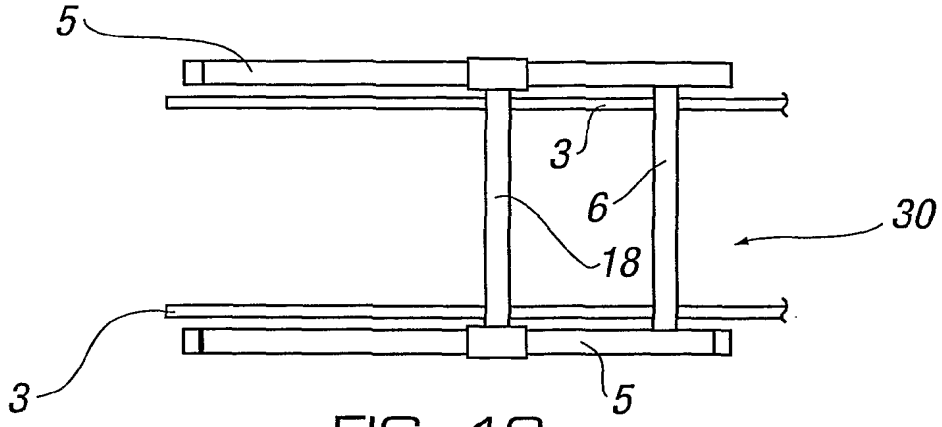


FIG. 10

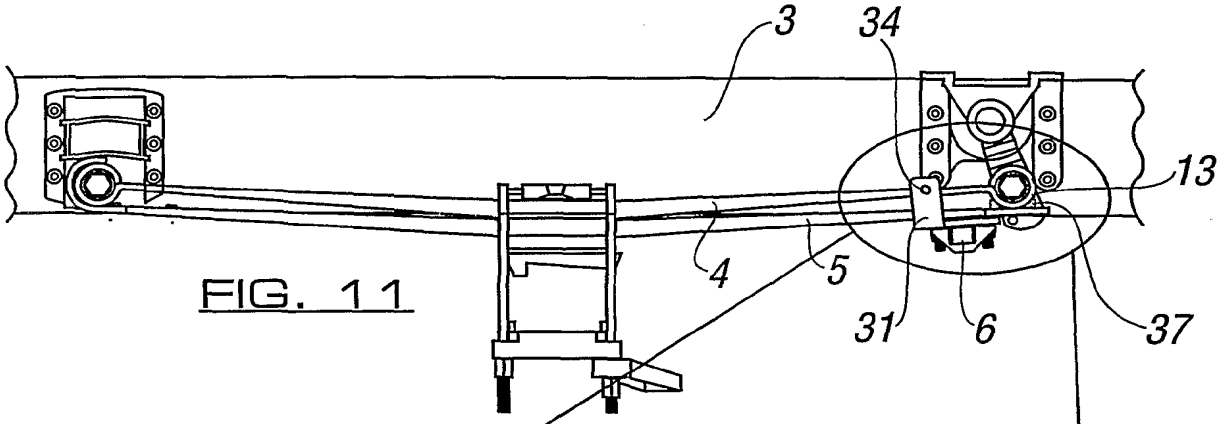


FIG. 11

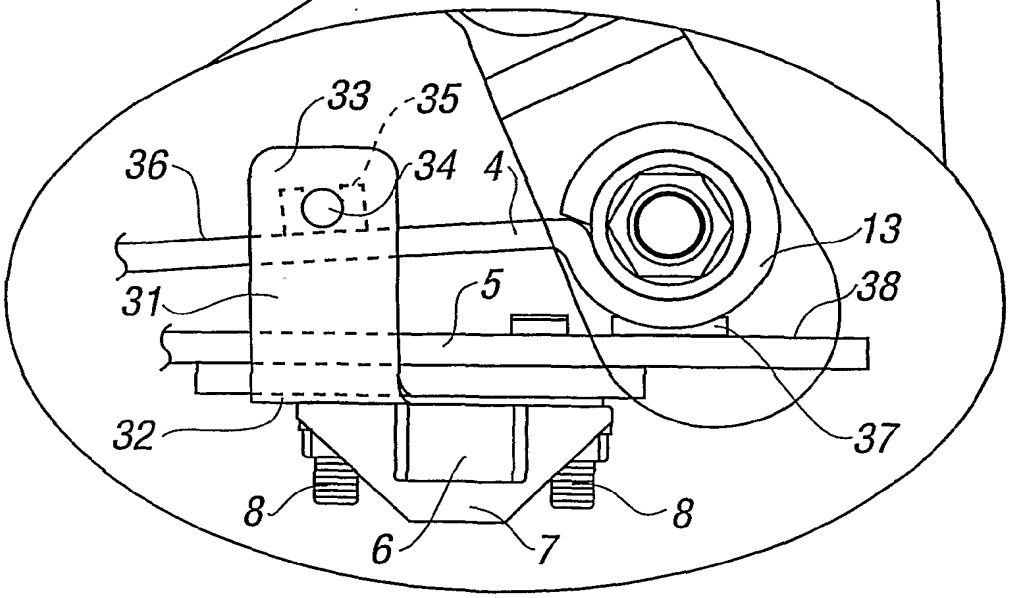


FIG. 12

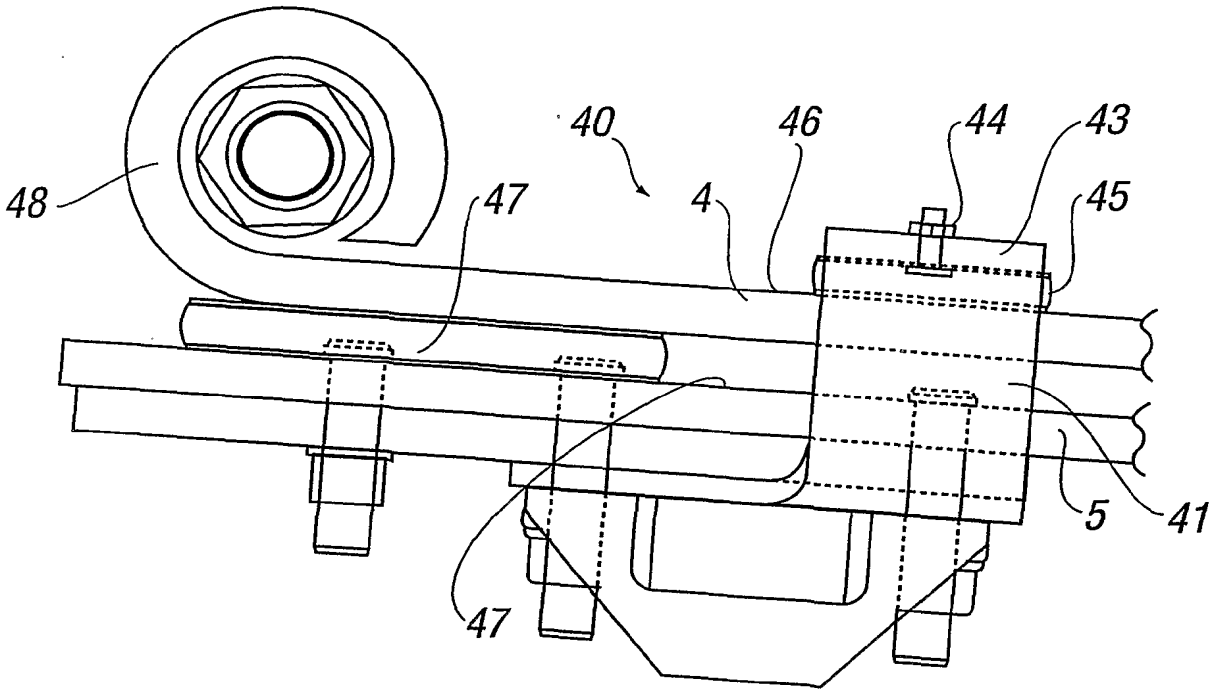


FIG. 13

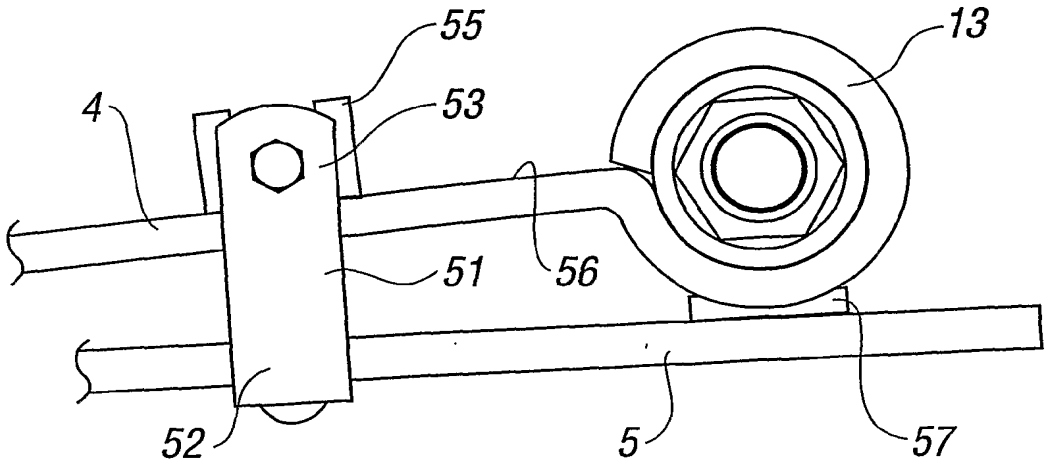


FIG. 14

INTERNATIONAL SEARCH REPORT

International Application No
PCT/US 00/32527

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 B60G11/02 B60G11/04 B60G21/055

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 B60G

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)
EPO-Internal, WPI Data, PAJ

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y A	EP 0 605 398 A (DETROIT STEEL PRODUCTS CO INC) 6 July 1994 (1994-07-06) column 8, line 16 - line 29 figure 11	1,11,14, 24 2,12,15, 25,27,28
Y	US 3 933 367 A (TAMAS ATTILA J) 20 January 1976 (1976-01-20) column 2, line 50 -column 3, line 18 figure 1	1,11,14, 24
A	WO 92 22438 A (DETROIT STEEL PRODUCTS CO INC) 23 December 1992 (1992-12-23) page 15, line 6 - line 34 figures 1,5,8	1,7,20

-/--

[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

° Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
31 July 2001	06/08/2001

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL – 2280 HV Rijswijk Tel. (+31–70) 340–2040, Tx. 31 651 epo nl, Fax: (+31–70) 340–3016	Savelon, O

Form PCT/ISA/210 (second sheet) (July 1992)

INTERNATIONAL SEARCH REPORT

International Application No
PCT/US 00/32527

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	GB 357 638 A (GEORGE ALFRED WOODHEAD;THOMAS HENRY SANDERS) 28 September 1931 (1931-09-28) figures 1,5	1
A	US 5 542 652 A (STUART JOHN W) 6 August 1996 (1996-08-06) column 2, line 45 -column 3, line 4 figures 2,4,5	5,6,18, 19
A	US 3 228 489 A (FORD MOTOR COMPAGNY) 11 January 1966 (1966-01-11) column 3, line 67 - line 75	9,22

INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No
PCT/US 00/32527

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
EP 0605398 A	06-07-1994	AT 132086 T	15-01-1996
		AT 143318 T	15-10-1996
		AU 5277190 A	22-10-1990
		CA 2050926 A,C	23-09-1990
		DE 69024487 D	08-02-1996
		DE 69024487 T	05-09-1996
		DE 69028721 D	31-10-1996
		DE 69028721 T	20-02-1997
		EP 0464082 A	08-01-1992
		ES 2083450 T	16-04-1996
		WO 9011201 A	04-10-1990
		JP 4505596 T	01-10-1992
		RU 2106550 C	10-03-1998
		US 5217248 A	08-06-1993
US 3933367 A	20-01-1976	CA 1011350 A	31-05-1977
WO 9222438 A	23-12-1992	AT 165286 T	15-05-1998
		AU 1908792 A	12-01-1993
		DE 69225225 D	28-05-1998
		DE 69225225 T	07-01-1999
		EP 0587663 A	23-03-1994
		ES 2114939 T	16-06-1998
		US 5507516 A	16-04-1996
GB 357638 A	28-09-1931	NONE	
US 5542652 A	06-08-1996	NONE	
US 3228489 A	11-01-1966	NONE	